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ABSTRACT

Designed as a 3-week course of study in the agricultural mechanics curriculum to be taught at the junior or senior high school level, this unit on electric motors is divided into 11 major performance objectives. Each objective is subdivided into the areas of content, suggested teaching and learning activities, resources, and evaluation. Topics for the 11 sections are (1) Electric theories and terms, (2) basic principles of electric motor operation, (3) major characteristics of electric motors, (4) major types of electric motors, (5) selection of proper motors for work situations, (6) selection of the correct motor drive, (7) selection of the correct motor pulley, (8) selection of V-belts, (9) selection of type of protective device or control, (10) wiring or hook-up of electric motors, and (11) servicing electric motors. Transparency masters illustrating the lessons are appended. (NJ)

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Electric Motors

An Instructional Unit for High School
Teachers of Vocational Agriculture

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UNIT: OPERATION AND SERVICE OF ELECTRIC MOTORS

Major Objective

Upon completion of this unit, the student will be able to operate and service electric motors.

Performance Objectives: The student will

- I. Define electric theories and terms related to the operation of electric motors.
- II. Identify the basic principles of electric motor operation.
- III. Identify the major characteristics of an electric motor.
- IV. Identify the major types of electric motors based on the motor parts.
- V. Select the proper motors for different work situations.
- VI. Select the correct motor drive.
- VII. Select the correct motor pulley.
- VIII. Select V-belts.
- IX. Select the type of protection (protective device or control) to provide for electric motors.
- X. Wire (hook-up) an electric motor.
- XI. Service electric motors.

UNIT: ELECTRIC MOTORS

Suggested Teaching Time

This unit concerning electric motors should take approximately three weeks to teach and should be taught in the classroom and the agricultural laboratory.

Place of the Unit in the Course of Study

The unit may best be taught during the junior or senior year as part of the regular agricultural mechanics course of study and should follow the unit on the principles of electricity. This unit could also be taught as part of the full-time agricultural mechanics program during the junior and/or senior years. Regardless of where it is taught, the unit should aid the student in developing an effectual ability to operate and service electric motors.

Suggestions for Introducing the Unit

In introducing the unit, the importance of electric motors should be stressed, i.e. electric motors are found on every farm today doing many different types of jobs.

Interest can be created by having the students make a list of the different uses of electric motors on their home farm. Point out to students that electric motors are popular for agricultural use because of their capacity to perform work efficiently at relatively low cost.

A field trip to a local farm where the students could see electric motors in use could also be a method of building student interest.

I. The student will define electrical theories and terms related to the operation of electric motors.

A. Content

1. Important electrical theories

a. Electron theory

- (1) The electron theory assumes all atoms to be composed of electrons and protons.
- (2) Electricity is defined as electrons in motion.
- (3) Protons
 - (a) Form nucleus of an atom
 - (b) Are stationary and do not cause electrical flow
 - (c) Carry a positive charge
- (4) Electrons
 - (a) Circulate about the protons in the nucleus of an atom
 - (b) Are relatively free to move
 - (c) Carry a negative charge
 - (d) Need a force or stimulus to cause electrons to line up or move in a definite direction
 - (e) Motion of electrons confined to a definite path which makes it possible for electricity to be harnessed and put to work

b. Theory of magnetism

- (1) The ability of a body to attract certain other materials
- (2) Magnets have two distinct poles, north and south.
 - (a) Like magnetic poles repel.
 - (b) Unlike magnetic poles attract.
- (3) Electromagnet is a magnet formed by a piece of soft iron in a coil of wire connected to an electrical supply.
- (4) An electromagnetic field exists around an electromagnet and the strength depends upon the following:
 - (a) Turns of wire in coil
 - (b) Amperes flowing in coil

(5) Examples of materials easily magnetized (magnetic materials):

- (a) Iron
- (b) Steel

(6) Examples of materials not easily magnetized (non-magnetic materials):

- (a) Wood
- (b) Glass
- (c) Copper

2. Common electrical terms

- a. Volt - A unit of measure of electrical pressure that causes current (electron) flow.
- b. Ampere - A unit used to express the rate of electrical flow in a conductor.
- c. Watt - A unit of electrical power. $\text{Watts} = \text{Volts} \times \text{Amps}$
- d. Kilowatt hour - One kilowatt hour equals 1000 watts used for a period of one hour.
- e. Resistance - The property of a substance to resist electrical flow. Resistance is expressed in Ohms.
- f. Conductor - A material which offers little resistance to the flow of electricity.
- g. Insulator - A material which resists the flow of electricity. Examples are rubber, glass and plastic.
- h. Alternating current - Alternating current (AC) changes direction of flow at a rate of 60 cycles per second (CPS).
- i. Direct current - Direct current (DC) flows in one direction.

B. Suggested Teaching-Learning Activities

- 1. Illustrate on the chalkboard the "free" electrons of an atom. Explain how the imbalance between the protons and electrons will allow electricity to flow.
- 2. Demonstrate the polarity of a magnet by using a bar or horseshoe magnet. The procedure to follow in conducting the demonstration can be found in the reference Farm Electricity, page 7.

3. Demonstrate the lines of magnetic force by using a horse-shoe magnet and iron filings. The procedure to follow in conducting the demonstration can be found in the reference Learning Electricity and Electronics Experimentally, pages 24-26.
4. Give the students a list of the electrical terms included in the content. Have them through research in teams or individually, determine the definitions of the terms.
5. Invite a local electrical representative into the classroom to discuss the basic principles of electricity.

C. Resources

1. Books

Electrical Fundamentals Useful in Engine Analysis, pp. 1-2, 3-18.

Farm Electricity, pp. 1-12.

Electrical Terms--Their Meaning and Use, pp. 1-8.

Learning Electricity and Electronics Experimentally, pp. 22-34.

Fundamentals of Service--Electrical Systems, p. 2.

2. Resource person

Electrical representative

D. Evaluation

1. Involve the students in a discussion of the electron and magnetic theories. Evaluate the students based on how well they can explain these theories.
2. Develop a list of electrical terms for each student to define and evaluate him based on the number of correct definitions made.

II. The student will identify the basic principles of electric motor operation.

A. Content

1. Operation of a simple electric motor dependent upon permanent magnets and electromagnets working together
 - a. Permanent magnets working together will cause a magnet to rotate due to like poles repelling and unlike poles attracting.
 - b. An electromagnet can be made from a piece of soft iron wrapped with insulated wire connected to an electrical source and magnetizes when current flows through the wire to the iron core.
 - c. An electromagnet field exists around the electromagnet and the strength of this field depends upon the turns of wire in the coil and the amperes flowing through the coil.
 - d. The polarity of the electromagnet can be changed by reversing the direction of the current flow in the wire.
 - e. To get rotation in an electric motor, an electromagnet is used with a permanent-type rotating magnet.
 - f. By changing the polarity of the electromagnet, the permanent magnet can rotate a complete turn.
 - g. The permanent magnets in a simple motor will continue to turn as the polarity is changed.
2. Development of a simple motor
 - a. A U-shaped electromagnet and a mounted bar magnet between the poles of the U-shaped electromagnet will make a simple motor.
 - b. The changing of the polarity of the electromagnet will cause the bar magnet to turn.
 - (1) AC automatically changes polarity due to surging reversing action of 60 cycles per second.
 - (2) Manually changing leads on a battery (DC) current will also cause the bar magnet to turn.

B. Suggested Teaching-Learning Activities

1. Use the following demonstration to show students how permanent magnets can be made to rotate.
 - a. Take two bar magnets and place them end to end on the desk. (N facing N - like poles repel.)
 - b. The magnets will repel each other causing one magnet to rotate.
 - c. Changing polarity of stationary magnet will allow the magnet to complete one turn.
2. Show the film, "How Electric Motors Start and Run," to illustrate how two magnets can be made to rotate and how a simple motor works.
3. Give a demonstration to show students how an electromagnet works. The procedure to follow in conducting the demonstration can be found on page 11 of the reference Farm Electricity.
4. Use demonstration to show students how an electromagnet and permanent magnet work together to make a simple motor. The procedure to follow can be found on page A-37.
5. Have students construct a simple electric motor.
6. Invite a local electrical representative into the classroom to discuss electric motors and their basic principles of operation.

C. Resources

1. Books
 - An Easy Understanding of Electricity, pp. 24-32.
 - Farm Electricity, pp. 49-53.
2. Resource person
 - Electrical representative
3. Film
 - "How Electric Motors Start and Run."

D. Evaluation

Have the students discuss, orally or in writing, the basic principles of electric motor operation. Evaluate the students based on how well they can explain the basic principles of electric motor operation.

III. The student will identify the major characteristics of an electric motor.

A. Content

1. Major characteristics of an electric motor

a. Bearings

(i) Type of bearings

- (a) Sleeve-type bearing has a brass or bronze cylinder in which the motor shaft rotates.

--Sleeve bearings are lubricated by oil in one of the following ways:

- Oil wick in an oil well
- Yarn packed to hold oil
- Ring oiled

(b) Ball bearing

--Ball bearings are used to carry the rotating motor shaft and consist of steel balls rotating in a metal cavity.

--Ball bearings are lubricated by grease which is recirculated by the rollers inside the bearing cavity.

--Methods of lubricating ball bearings

- Prelubricated and sealed at the factory
- Disassembled and hand packed
- Lubricated through grease fitting

(2) Comparison of sleeve and ball bearings

- (a) Sleeve bearings are less expensive, require more frequent service and are less durable than ball bearings.
- (b) Sleeve bearings cannot be used for all operating positions while ball bearings can.

b. Motor enclosures

(1) Types of enclosures

(a) Drip-proof (open) enclosures

- Openings in each end shield to allow easy air movement
- Used where dusty conditions are not a problem
- Can have no water near the motor
- Least expensive motor due to type of enclosure

(b) Splashproof

- Designed to keep free water from splashing into the motor
- Openings or vents designed so that water will drain off the motor without entering openings
- Splashproof enclosure motor approximately 15-20 percent more expensive than drip-proof

(c) Totally enclosed motor

- Provides no openings for circulation of outside air through the motor
- Air inside the motor recirculated throughout the motor
- Totally enclosed motors protected from dirt and water
- Totally enclosed motors 20-40 percent more expensive than drip-proof

(2) Factors that affect the type of motor enclosure used

- (a) Temperature
 - (b) Exposure to corrosive materials
 - (c) Presence of explosive gases
 - (d) Submersion of water or liquid
- Note: The last three conditions require a totally enclosed motor.

c. Motor mounts

(1) Purpose of motor mounts

- (a) Provide a means for anchoring the motor in position
- (b) Provide a means for adjusting belts

- (c) Provide correct alignment of the motor
- (d) Reduce motor vibration noise

(2) Common types of motor mounts

(a) Rigid base

- Most common type of base used on fractional horsepower motors
- Means of adjusting

- Slotted holes on the base
- Rigid base with adjusting screw
- Sliding rails on larger motors

(b) Cushion base

- Motor base of mount provides rubber cushion support to dampen vibration noise

B. Suggested Teaching-Learning Activities

1. Prepare a display to show the different characteristics of electric motors.
2. Invite a local electrical representative or electric motor repairman to the classroom to discuss the major characteristics of electric motors.
3. Show transparency HS 53 B-1, "Types of Motor Enclosures," page A-38, and identify the different types of motor enclosures.
4. Show transparency HS 53 B-2, "Lubrication of Sleeve Bearings," page A-39, and identify the different methods of lubricating sleeve bearings.

C. Resources

1. Books

Electric Motors, Selection, Protection, and Drives, pp. 21-28.

Using Electricity on the Farm, pp. 229-233.

2. Bulletins and Circulars

"Single-Phase Electric Motors for Farm Use," pp. 8-12.

3. Resource person

Local electrical representative or electric motor repairman

4. Transparencies

HS 53 B-1-2, pp. A-38-39.

D. Evaluation

Show samples of the different motor enclosures, bearings, and mounts and have the students identify each type. Evaluate the students on the basis of the number of correct identifications.

IV. The student will identify the types of electric motors based on the motor parts.

A. Content

1. The identification of the types of electric motors must be based on the motor parts.

2. Types of motors

a. Split-phase

(1) Parts of Split-phase motor

(a) End bell - (end shield)

- Part of the motor enclosure
- Carries the bearing(s) of the motor

(b) Stator - (main windings - also called running windings)

- The electrical windings that carry the electrical current from the power source
- Builds up the electromagnetism in the motor
- Main windings of the motor

(c) Stator frame

- Outside frame or enclosure of the electric motor
- Stator or main windings attached to the stator frame

(d) Starting windings

- Smaller number of windings than main windings or stator
- Starter windings parallel with the main windings but have a higher resistance
- Difference in resistance from the main windings gives phase displacement of from 20-30 degrees which gives motors sufficient torque to start a small load

(e) Rotor

- A rotating permanent magnet

(f) Cooling fan

- Part of the rotor and/or may be attached as a separate fan in the motor shaft
- Causes air flow through the motor to give cooling

(g) Centrifugal switch

- Disconnects the starting windings when the motor reaches 75-80 percent of full speed

(h) Drive shaft

- Drive shaft runs through the center of motor and carries the starter, cooling fan, centrifugal switch, thrust washers and motor bearings
- Motor pulley(s) attached to the drive shaft to make use of the motor's power

(i) Thrust washers

- Keep the stator from having end vibrations

(j) Bearings

- Carry the drive shaft of the motor
- May be sleeve or ball bearing type

(k) Mounting

- Motor mounting used to anchor the motor to a particular piece of equipment

(l) Cooling vents

- Used to allow air current to pass through the motor for cooling (found on all motors except totally enclosed)

(m) End bell shield bolts

- Bolts used to hold end shields and motor frame together into one single unit

(n) Nameplate

- Furnishes information needed for replacement or installation of electric motor

b. Capacitor motor

- (1) All parts A through N of split-phase motor also apply to capacitor motor
- (2) Additional part--capacitor
 - (a) An electrical condenser mounted in a cylinder externally and/or internally
 - (b) Used to increase starting torque
 - (c) Enables the motor to start a heavier load than just simple split-phase motors

c. Universal or series motor

- (1) All parts A through N of split-phase motor also apply to universal motor
- (2) Additional parts
 - (a) Brushes
 - Ride on the commutator and conduct current through the rotor to the other stator coil
 - (b) Commutator
 - Conducts current from one brush and through the rotor and to the other brush

B. Suggested Teaching-Learning Activities

1. Disassemble the different types of motors for the students to identify the parts.
2. Show transparency HS 53 B-3, "Split Phase Motor," page A-40, to identify the parts of a split-phase motor.
3. Show transparency HS 53 B-4, "Capacitor Motor," page A-41, to identify a capacitor motor.
4. Show transparency HS 53 B-5, "Universal Motor," page A-42, to identify the parts of a universal motor.
5. Have students either individually or as teams disassemble and reassemble an electric motor.
6. Have students identify different types of motors based on the motor parts.

C. Resources

1. Books

Using Electricity on the Farm, pp. 219-220.

2. Transparencies

HS 53 B-3-5, pp. A-40-42.

D. Evaluation

Have the student identify the types of electric motors based on the different parts. Evaluate the student on the number of correct identifications.

V. The student will select the proper motors for different work situations.

A. Content

1. Importance of selecting correct motor

- a. Must be large enough to perform the job
- b. Prevents overheating due to overload
- c. Prevents overall damage to motor and equipment

2. Sizes of motors from which to select

- a. Fractional horsepower motors are commonly available in sizes $1/8$, $1/6$, $1/4$, $1/3$, $1/2$, and $3/4$ hp.
- b. Larger motors are usually available in 1, $1\ 1/2$, 2, 3, 5, $7\ 1/2$, 10 hp and up.

3. Basis for selecting electric motors

a. Electrical supply

(1) Most supplies of electricity are single-phase.

- (a) Most power suppliers will serve motors up to $1/2$ horsepower on 120 volt circuit and from $1/2$ to 3 horsepower on 240 volt circuit.
- (b) When using electric motors of 5 hp or larger, certain electrical rules must be followed.

--Example: If a single-phase service is all that is available, many electrical standards will not permit motors larger than 5 hp. (Some may permit up to $7\ 1/2$ hp.)

(2) Some suppliers will supply 3-phase power.

- (a) If larger than 5 hp electric motor is needed, check with power supplier on availability of power.
- (b) If 3-phase electricity is available, larger motors may be used.

b. Size of service entrance (SE)

- (1) For motors 1/3 hp or less, the SE is no problem because the motor can be connected to a 115-120 volt convenience outlet.
- (2) For motors 1/2 hp or larger, the service entrance may limit the size of motor you can install.

--Example: A 60-ampere service entrance is used and it is already serving an electric range; it is very doubtful that a 5 hp electric motor could be used satisfactorily without overloading the service entrance and blowing the main fuse.

- (3) The location of the service entrance affects the size SE needed.

- (a) A central distribution point will improve current distribution.
- (b) Smaller electrical lines can be used if the SE is centrally located.

c. Type of motor needed based on starting load

- (1) Motors needed for "easy starting" loads (Easy starting loads means the motor does not have to start under full load.)

(a) Shaded-pole-induction

- Very low starting torque, 50% to 100% of its running torque
- Used for light duty, such as small fans, freezer blowers, hair dryers, small tool grinders

(b) Split-phase motor

- Low starting torque of 100-150% of the running torque
- Moderate to light duty, such as fans, furnace blowers, lathes, small shop tools

(c) Other motors available for easy starting loads

- Permanent-split-capacitor
- Soft start

(2) Motors needed for difficult starting loads

(a) Capacitor start-induction run

- Gives long service, low maintenance
- Used commonly in water systems, air compressors, ventilating fans and grinders

(b) Repulsion start-induction run

- Handles large load variations with little variation in current demand
- Used in grinders, deep-well pumps, silo unloaders, grain convey or barn cleaners

(c) Other motors available for difficult starting loads

- Repulsion-start, induction-run
- Capacitor-start, capacitor-run
- Three-phase, general purpose

B. Suggested Teaching-Learning Activities

1. Involve the students in a discussion of the importance of correct motor selection.
2. Make a list of the motors used on the students' farms. Identify the probable size of these motors.
3. Bring examples of easy and difficult starting load motors into the classroom or shop for the students to identify.
4. Invite a local electrical representative into the classroom to discuss the factors to consider in motor selection.
5. Refer to publication Electric Motors by AAVIM, p. 15 and make a comparison of the electric motors based on type of load.
6. Show transparency "Motor Size in Relation to Service Entrance," HS 53 B-6, page A-43, to show the size motors that may be used with common size service entrances.

C. Resources

1. Books

Electric Motor, Selection, Protection and Drives, pp. 6-20.

Farm Electricity, pp. 51-52.

Using Electricity on the Farm, pp. 223-233.

2. Bulletins and Circulars

"Single-Phase Electric Motors for Farm Use," pp. 7-10.

3. Resource people

Local electrical representative

Person from a local electric motor repair shop

4. Transparency

HS 53 B-6, page A-43.

D. Evaluation

Develop hypothetical situations of different conditions for motor selection. Have the students select electric motors for these conditions. Evaluate the students based on the number of correct selections.

VI. The student will select the correct motor drive.

A. Content

1. Type of motor drives

a. Direct drives

- (1) Used for connecting a motor to equipment that runs at the same speed as the motor. For example, if your equipment runs 1725 RPM and your motor runs at the same speed, they can be connected directly to one another.

- (2) Types of direct drives

- (a) Flexible-hose coupling

--The ends of the hose are simply pushed over the ends of the motor and equipment shafts are clamped into position.

- (b) Flange coupling

--Fastening of one-half of the flanged coupling to the motor shaft and other one-half to the shaft of the equipment to be driven. The two halves are then fastened to a flexible disk which provides for flexing.

- (c) Cushion-flange coupling

--Hooking of two flanges to a tire shaped segment

--More flexible and comes in larger sizes than the regular flange coupling

- (d) Flexible shaft

--Used mainly on portable tools such as buffer, wire brush and emery wheel

b. Speed-conversion drives

- (1) Used for motors that do not turn at the recommended RPM of the equipment, or vice versa.
- (2) Used to reduce motor speed to equipment being operated, or increase equipment speed to that of the motor.

(3) Types of speed-conversion drives

(a) Pulley-and-belt drive

--V-belt consists of two V-pulleys, one on the motor and one on the driven equipment connected by a V-belt. (May be more than one belt)

--Webbed multi-V-belt drive is a combination of two or more V-belts webbed together as one belt.

--Flat-belt drive is a flat belt on two flat pulleys, one on motor and one on the piece of equipment.

--V-flat drive has a V-pulley on the motor and a flat pulley on the driven equipment.

(b) Gear Drive

--Motor and gears are connected together in one unit and offer little opportunity to change or alter speed.

(c) Chain-and-sprocket drives

--Equipment is driven by sprockets and chains.

2. Selecting motor drives based on the use of the equipment

a. Select direct drive where the motor and equipment are operated at same RPM.

(1) On motors 1/3 hp or less, use a flexible hose coupling.

(2) On motors 1/3 hp or more, use a flanged or cushioned type coupling drive.

(3) On motor of any size up to 2 hp, flexible drives of the correct size are used.

b. Select pulley-and-belt drives when motor speeds are different or the equipment being operated is located away from the motor.

c. Select gear-drive and chain-and-sprocket drives when heavier equipment is used.

(1) Purchase drives matched to hp motor needed and RPM needed.

(2) These drives are more expensive to purchase.

B. Suggested Teaching-Learning Activities

1. Conduct a discussion concerning the importance of selecting correct motor drives.
2. Have the students identify the different motor drives found in the agricultural shop.
3. Visit a local farm to see the different types of motor drives in use.
4. Show transparency HS 53 B-7, "Types of Direct Drives," page A-44, and identify the different types of direct drives.
5. Show transparency HS 53 B-8, "Types of Pulley and Belt Drives," page A-45, and identify the different types of pulley and belt drives.
6. Show transparency HS 53 B-9, "Gear Drive," page A-46, and discuss the characteristics of the gear drive.
7. Show transparency HS 53 B-10, "Chain and Sprocket Drive," page A-47, and discuss the characteristics of the chain and sprocket drive.
8. Have students to identify the different motor drives found on a field trip to a local farm.

C. Resources

1. Books

Electric Motors, Selection, Protection and Drives, pp. 39-44.

Using Electricity on the Farm, pp. 233-241.

2. Transparencies

HS 53 B-7-10, pp. A-44-47.

D. Evaluation

Develop hypothetical situations which would require the selection of different motor drives. Involve the students in selecting the correct motor drive for these situations. Evaluate the students based on the number of correct selections.

VII. The student will select the correct motor pulley.

A. Content

1. Type of pulleys from which to select

a. Standard V-pulley

- (1) Most common pulley used
- (2) Least expensive pulley
- (3) Usually used if motor is performing only one function

b. V-step pulley

- (1) Used where a variety of speeds is desired
- (2) Without changing pulleys motor can be used on different jobs requiring different RPM's by changing placement of the belts

c. Adjustable V-pulley (adjustable sheave)

- (1) One side of pulley adjusted in or out to give more or less effective diameter
 - (2) Very expensive pulley
 - (3) Not commonly used on the farm
- Note: For larger power uses where two or more belts are needed, use a standard V-pulley with as many grooves as needed.

2. Methods used to select pulleys

a. Pulley selection chart which is used for motors turning 1725 RPM's

b. Pulley selection formula: $\text{RPM of motor pulley} \times \text{diameter of motor pulley} = \text{RPM of equipment} \times \text{diameter of equipment pulley}$

- (1) Use the pulley selection formula if the pulley selection chart is not available or if your motor and equipment turn at different speeds.
- (2) Steps to follow in using the formula

Situation: Find pulley size needed on equipment which operates at 2100 RPM using a motor which operates at 1725 RPM.

- (a) Choose diameter of motor pulley or equipment pulley.

--Select 3 inch motor pulley for the example presented.

- (b) Have 1725 RPM motor pulley
(c) Equipment needs 2100 RPM equipment pulley
(d) Plug the three knowns into the formula and find the size pulley needed on the equipment.

--Procedure: $\text{RPM of motor} \times \text{diameter of motor pulley} = \text{RPM equipment pulley} \times \text{diameter of equipment pulley}$

-- $1725 \times 3 = 2100 \times \text{diameter of equipment pulley}$

--Diameter of equipment pulley = $\frac{1725 \times 3}{2100}$

--Diameter of equipment pulley = 2.46 inches

--Solution: Use 2 1/2 inch pulley

Note: Formula can be used to find any one of the unknowns.

c. Combination of pulley chart and formula for speeds less than 200 RPM using jackshaft

- (1) For speeds less than 200 RPM, a jackshaft should be used.
(2) A jackshaft is a shaft with pulleys mounted between the motor pulley and equipment pulley to increase or decrease speed.
(3) Procedure to follow to calculate pulley needed

- (a) Determine speed of the first jackshaft pulley by using pulley selection chart.
(b) Choose diameter of second jackshaft pulley
(c) Use formula to find the size of diameter pulley needed on the equipment

--Example of selecting pulley with jackshaft

Situation: Want a piece of equipment to run 70 RPM. Have a 1725 RPM motor hooked to a 12" jackshaft pulley.

--From pulley selection chart, it is determined the first jackshaft pulley turns 285 RPM.

--Choose second jackshaft pulley. Use a 2" pulley for the example.

- Use formula - $\text{RPM of motor pulley} \times \text{diameter of motor pulley} = \text{RPM of equipment pulley} \times \text{diameter of equipment pulley}$.
- $285 \times 2 = 70 \times \text{diameter of equipment pulley}$
- Diameter of equipment pulley = $\frac{285 \times 2}{70}$
- Diameter of equipment pulley = 8.14 inches
- Answer: Use an 8 inch pulley.

B. Suggested Teaching-Learning Activities

1. Have students identify all the pulleys found on the agricultural shop equipment.
2. Have students select correct pulley combinations by using the following methods:
 - a. Pulley selection chart which can be found in Electric Motors by AAVIM, p. 46
 - b. Pulley selection formula
 - c. Combination of pulley chart and formula for speed less than 200 RPM using jackshaft
3. Set up a display of all the different types of pulleys. Involve the students in identifying the different types.
4. Show transparency HS 53 B-11, "Use of a Jackshaft," page A-48, to illustrate how a jackshaft can be used.

C. Resources

1. Books
 - Electric Motor, Selection, Protection and Drives, pp. 44-47.
 - Using Electricity on the Farm, pp. 233-235.
2. Transparency
 - HS 53 B-11, page A-48.

D. Evaluation

Give students problems to work concerning the selection of the correct combination of motor pulleys and equipment pulleys to get the desired equipment speed. Evaluate the students on the basis of the number of correct calculations.

VIII. The student will select V-belts.

A. Content

1. Types of V-belts available

Note: Belts are classified according to cross-sectional sizes.

a. Standard type - FHP

- (1) Used best with pulleys that are 2 1/2 inches or less in diameter
- (2) Belts are thinner and more flexible

b. A-section belt

- (1) Heavier than the FHP belt but there is more slippage than thinner belt due to the stiffness of the belt
- (2) A-section belt should not be used on a pulley smaller than 3" in diameter

c. B,C,D,E section belts

- (1) Cross-sectional sizes increase with these belts in progressing order.
- (2) These belts would be used on larger motors.

2. Sizes of V-belts available

- a. FHP - (fractional horsepower) belts have approximately 3/8 inch cross-section measurement on outside of belt.
- b. A-section belts have approximately 1/2 inch cross-sectional measurement on outside of belt.
- c. B-section belt has approximately 21/32 inch cross-sectional measurement on outside of belt.

Note: The cross-section measurement of V-belts fits the pulley with the same measurement.

3. Select correct type V-belt based on the size of the motor and the diameter of the pulley

Note: Charts are provided by the local equipment dealers or in publications such as Electric Motors by AAVIM p. 48 to assist in selecting the correct type of V-belt.

4. Determine the length of V-belts needed

- a. Measure length of V-belt needed with a flexible tape if the motor is already mounted.
- b. Check operator's manual.
- c. Use formula to determine length when motor does not have to be mounted in a certain place.

(1) 4 x diameter in inches of largest pulley _____
1.6 x diameter in inches of motor pulley _____
1.6 x diameter in inches of equip. pulley _____

Total length belt needed equals _____ inches

B. Suggested Teaching-Learning Activities

1. Have the students identify the type of V-belts used in the agricultural shop equipment.
2. Involve the students in using various methods to select the correct size and length of V-belt needed.
3. Involve the students in determining the different types of V-belts used on their home farm. Have them determine the size and length of these V-belts.

C. Resources

1. Books

Electric Motors, Selection, Prevention and Drive, pp. 47-49.

Using Electricity on the Farm, pp. 235-239.

D. Evaluation

1. Have students identify the belts on equipment in agriculture shop. Evaluate students on the basis of correct identifications.
2. Involve the students in calculating the correct size and length of V-belts needed in various situations. Evaluate the students based on the correctness of the calculations.

IX. The student will select the type of protection (protective device or control) to provide electric motors.

A. Content

1. Motor controls are used to protect motors from loads too heavy and from low voltage.

2. Types of motor controls

a. Built-in motor overload protection

(1) Manual-reset type

(a) Operates on heat (thermal bimetallic strip principle)

(b) Have to reset tripped mechanism by hand

(2) Automatic-reset type

(a) Operates on heat (thermal bimetallic strip principle)

(b) Tripped mechanism resets automatically

Note: Either type control or device may be plugged in directly or connected to a disconnect box.

b. Manual starting switch with overload protection

(1) Operates on the thermal bimetallic strip principle to disconnect the circuit in case of difficulty

(2) Methods used to disconnect circuit includes heating coil and heating strip

c. Magnetic starting switch with overload protection

(1) Has same type of overload protection as the manual type switch.

(2) Difference between manual and magnetic switches lies in the magnetic starting.

(3) Operates on thermal bimetallic strip principle and circuit can be disconnected using heating strip or heating coil.

d. Time-delay fuse in motor disconnect switch

- (1) Used for temporary overloads
- (2) Time-delay fuse will allow motor to handle temporary overload, such as starting.
- (3) Fuse has to be replaced if circuit is opened by the fuse.
- (4) In case of short-circuit, the fuse link will blow before solder cup melts.
- (5) Types of time delay fuses
 - (a) Plug fuse
 - Fusetron plug fuse that fits the standard plug-fuse socket
 - Fusestat that has a special adapter to prevent changing ampere size
 - (b) Cartridge fuse
 - Available with time-delay

e. Current-limiting (resistor) starter

- (1) Recommended for simple-phase motors of 7 1/2 hp or larger
- (2) Uses a resistor starter with a manual switch with overload protection
 - (a) As the operator gradually turns the switch to the running position, the resistor limits current flow until the motor gradually picks up speed.
 - (b) As motor picks up speed more current is fed to circuit.
 - (c) Switch is held in running position by electromagnet.

3. Basis for selecting the type of protective device to use

a. Size of motor

- (1) The following table gives types of controls that are suitable for different size motors

<u>Size of Motor (Horsepower)</u>	<u>Type of Control and Overload Protection</u>
0 - 1/3	Built-in overload protection in motor
1/2 - 2	Built-in overload protection in motor
1/2 - 3	Manual starting switch overload protection
5 or larger	Magnetic starting switch with overload protection
Any size	Time-delay fuse in motor disconnect box
7 1/2 or larger (single-phase)	Current limiting (resistor) starter, manual starting switch with overload protection

- (2) Select motor controls that have the recommended amperage rating.

- (a) Built-in protective devices are built into the motor and no selection has to be made.
- (b) Magnetic starting switch with overload, manual starting switch with overload, time delay fuses, and current-limiting (resistor) starter control devices have to have the correct ampere rating selected as shown on the nameplate.

- (3) Use automatic reset type control where motors are not checked very often, such as air conditioners, water pump or crop dryers

b. Use of motors - (type of operation)

- (1) Manually controlled devices

- (a) These can use any type device.

- (b) Time-delay fuse in disconnect box will provide good protection for almost any type of operation.
- (2) Remote control devices use magnetic starting switch with overload protection.
- (3) Automatic reset type control should not be used where there is danger of accidents if motor should suddenly come back on.

B. Suggested Teaching-Learning Activities

1. Discuss the importance of proper protection for electric motors.
2. Identify the types of motor controls on the equipment in the agricultural shop.
3. Involve the students in using the nameplate on the motor to determine size of control needed.
4. Have a local electrical representative or electric repairman discuss the importance and different types of electric motor controls.
5. Show transparency HS 53 B-12, "Types of Reset Buttons," page A-49, and identify the locations of the different types of reset buttons.
6. Show transparency HS 53 B-13, "Operation of Automatic Reset Protection," page A-50, and discuss how the automatic protection operates.
7. Discuss with the students the different types of motor controls.
8. Involve the students in selecting the correct protection for various types of motors.

C. Resources

1. Books

Electric Motor, Selection, Protection, and Drives, pp. 29-37.

2. Resource person

Local RECC representative

Local electric motor repairman

3. Transparencies

HS 53 B-12-13, pp. A-49-50.

D. Evaluation

Have students identify the controls found on equipment in the agricultural shop. Evaluate the students on the basis of the number of correct identifications.

X. The student will wire (hook-up) an electric motor.

A. Content

1. Factors to consider

a. Correct wire size

- (1) The amount of motor load affects the size wire needed.
 - (a) Load refers to number of amps and volts the motor uses.
 - (b) Check motor nameplate concerning amperage and voltage used.
- (2) The distance the motor is from SE (Service Entrance) will affect size of wire required.
 - (a) The greater the distance the motor is from the SE, the larger the wire needed.
 - (b) For wire specifications consult the electrical code.

--National Electric Code (NEC)
--Agricultural Wiring Handbook
--Local code (if in effect)

b. Tools and equipment needed

- (1) Wire
- (2) Motor control
- (3) Motor
- (4) Disconnect box, unless using direct plug
- (5) Wire cutter
- (6) Screwdriver
- (7) Knife or wire stripper
- (8) Wiring diagram of switch and motor
- (9) National Electric Code

c. Procedure to follow in wiring in a motor

- (1) Run wire from SE to disconnect box (if used).
- (2) Wire in disconnect box.
- (3) Run wire from disconnect box to motor control according to disconnect wiring diagram.
- (4) Wire motor control according to motor control diagram on motor nameplate.
- (5) Run wire from control to motor.
- (6) Wire motor according to wiring diagram.

B. Suggested Teaching-Learning Activities

1. Draw a simple schematic of the motor circuit. Use this schematic to illustrate how to hook-up an electric motor.
2. Wire in an electric motor from the SE. (Panel board can be used here.)
3. Discuss the electrical code with students and show them how to use the code.
4. Have local electrical representative demonstrate the proper method of wiring an electric motor.

C. Resources

1. Books

Electric Motors, Selection, Prevention and Drives, pp. 29-37.

Agricultural Wiring Handbook, Section 24 plus proper wiring tables.

Using Electricity on the Farm, pp. 260-263.

2. Bulletins and Circulars

"Single-Phase Electric Motor," pp. 12-18.

D. Evaluation

1. Have students draw a simple schematic of a motor wiring circuit. Evaluate the students on the basis of their understanding of the steps to follow in correct wiring.

2. Have students wire an electric motor. Evaluate the students on the basis of their ability to complete the skill.
3. Involve the students in using the electrical codes to check wiring specifications. Evaluate students on the basis of their ability to find the specifications.

XI. The student will service electric motors.

A. Content

1. Importance of servicing
 - a. Increases life of the motor
 - b. More efficient motor operation
 - c. Prevents expensive motor breakdown
2. Steps in providing service to electric motors
 - a. Clean dust from cooling passages.
 - (1) Wipe motor off on regular inspections.
 - (2) Use compressed air to clean dust from motor (never over 40 psi).
 - (3) Use vacuum cleaner to remove dust, etc.
 - b. Check bearings for wear.
 - (1) Check for play of bearings (side play, end play).
 - (2) Replace worn bearings with new bearings.
 - c. Lubricate motors according to motor specifications.
 - (1) Oil motor only while stopped, especially sleeve bearing with oil rings.
 - (2) Use clean oil with correct viscosity.
 - d. Check wiring.
 - e. Clean starting and stop switches.
 - f. Clean commutators and brushes on universal and repulsion-induction motors.
 - (1) Clean commutators with fine sandpaper; never use emery cloth.
 - (2) Replace brushes if they become excessively worn.
 - g. Check alignment being sure motor pulley(s) are in correct alignment with the equipment pulley.

- h. Check belt tension for correct adjustment using ruler and small weight scale.
- i. Check tightness of pulley to protect against motor shaft damage or pulley coming off during operation.
- j. Check shields.
 - (1) Replace any broken motor or belt shields.
 - (2) Correct the adjustment of shields.
- k. Check electrical current.
 - (1) Use volt meter to check for low voltage.
 - (2) Use ammeter to check for low amperage.

B. Suggested Teaching-Learning Activities

- 1. Have students develop a list of services to carry out for proper motor care.
- 2. Have students troubleshoot motors in the agricultural shop.
- 3. Involve students in a discussion of the importance of servicing electric motors.
- 4. Involve each student in servicing one motor.

C. Resources

- 1. Books

Using Electricity on the Farm, pp. 233-245.

D. Evaluation

Involve each student in servicing an electric motor. Evaluate him based on the steps discussed in class.

APPENDIX

DEMONSTRATION OF AN ELECTROMAGNET AND A PERMANENT MAGNET FORMING A MOTOR

Steps to Follow:

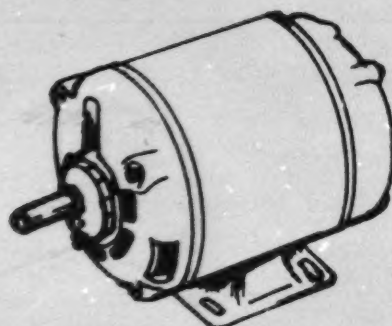
1. Take a stationary electromagnet and hook to a battery. Place a bar magnet at the end.

When N pole of the bar magnet rotates to meet S pole of the electromagnet, change the polarity of electromagnet to N to cause the bar magnet to continue to rotate.

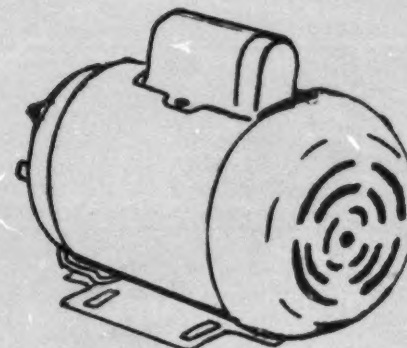
2. By manually changing the direction of current flow the bar magnet will rotate.

Note: In an electric motor we use alternating current to change direction of current flow.

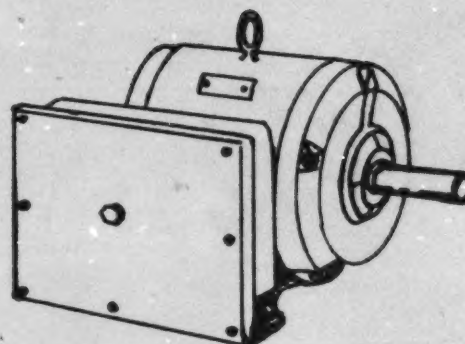
ENCLOSURES



DRIPPROOF

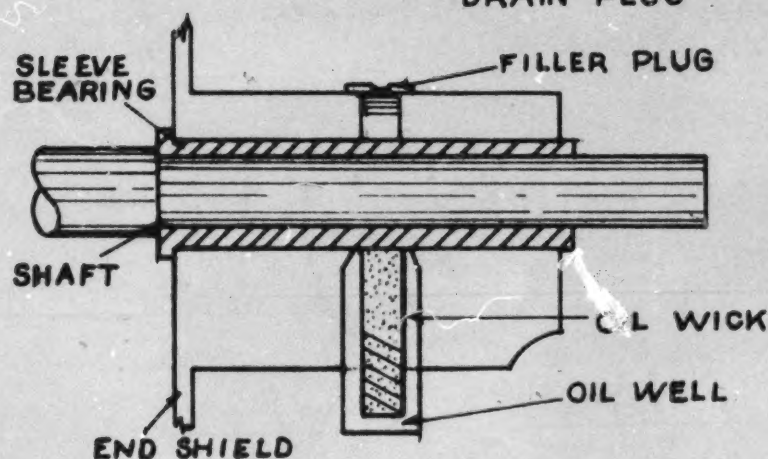
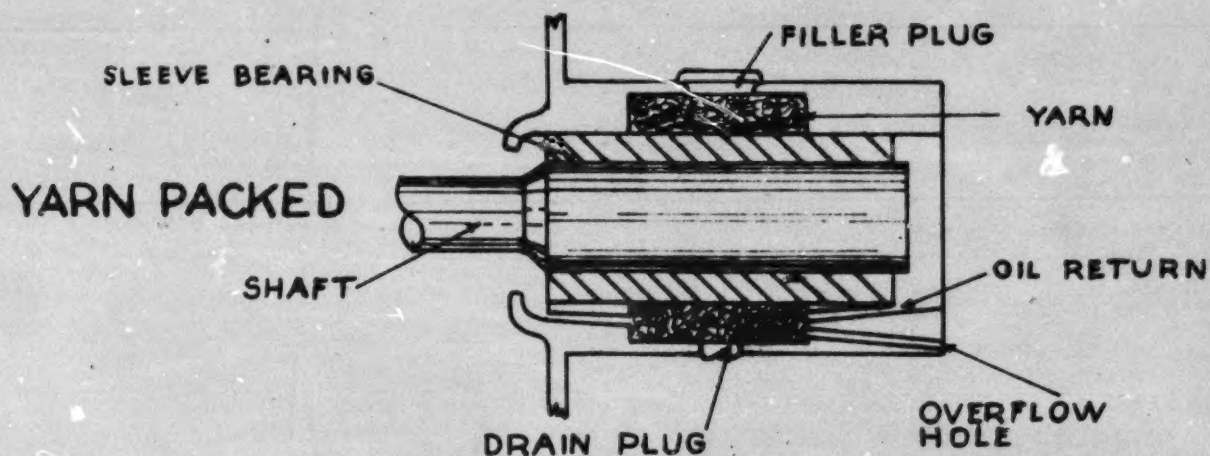


TOTALLY-ENCLOSURE MOTOR

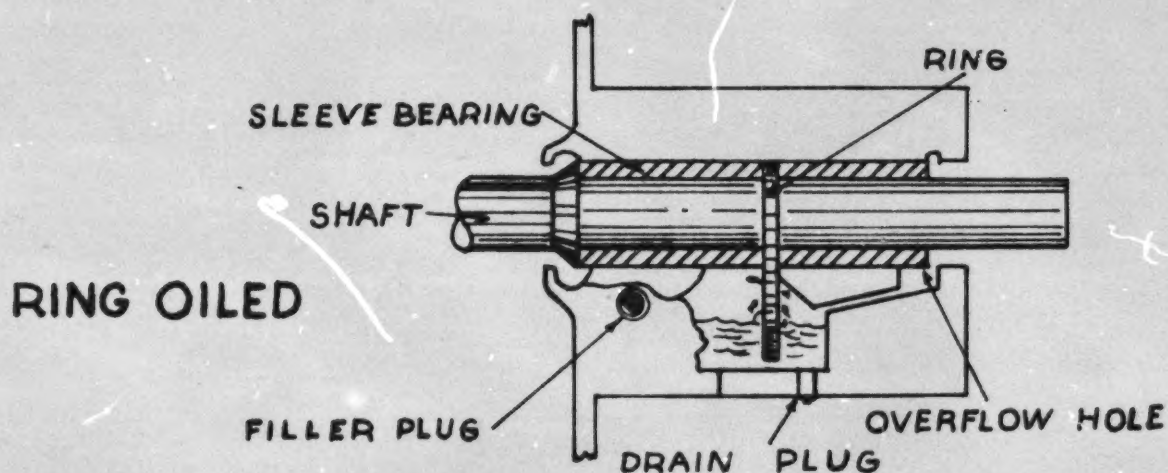


SPLASHPROOF

LUBRICATION OF SLEEVE BEARINGS

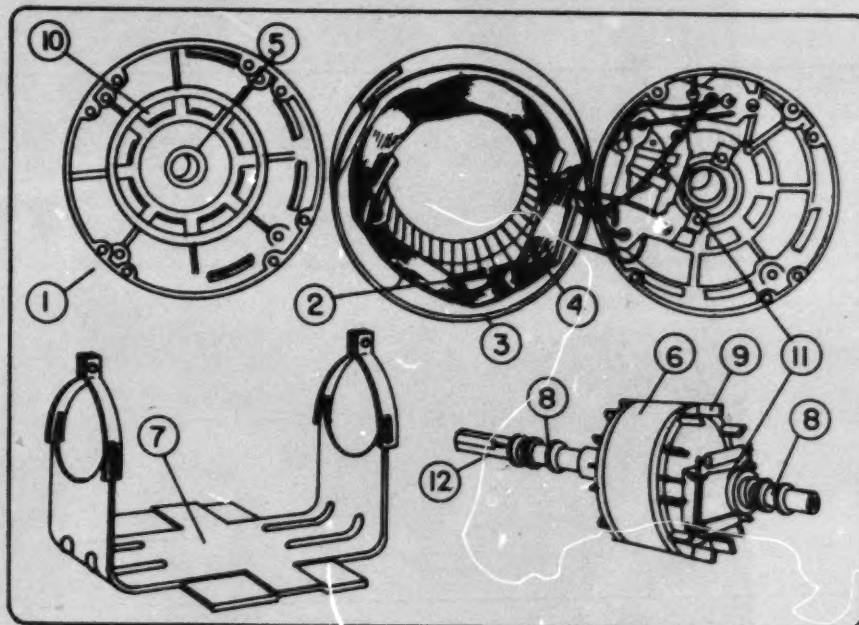


OIL WICK

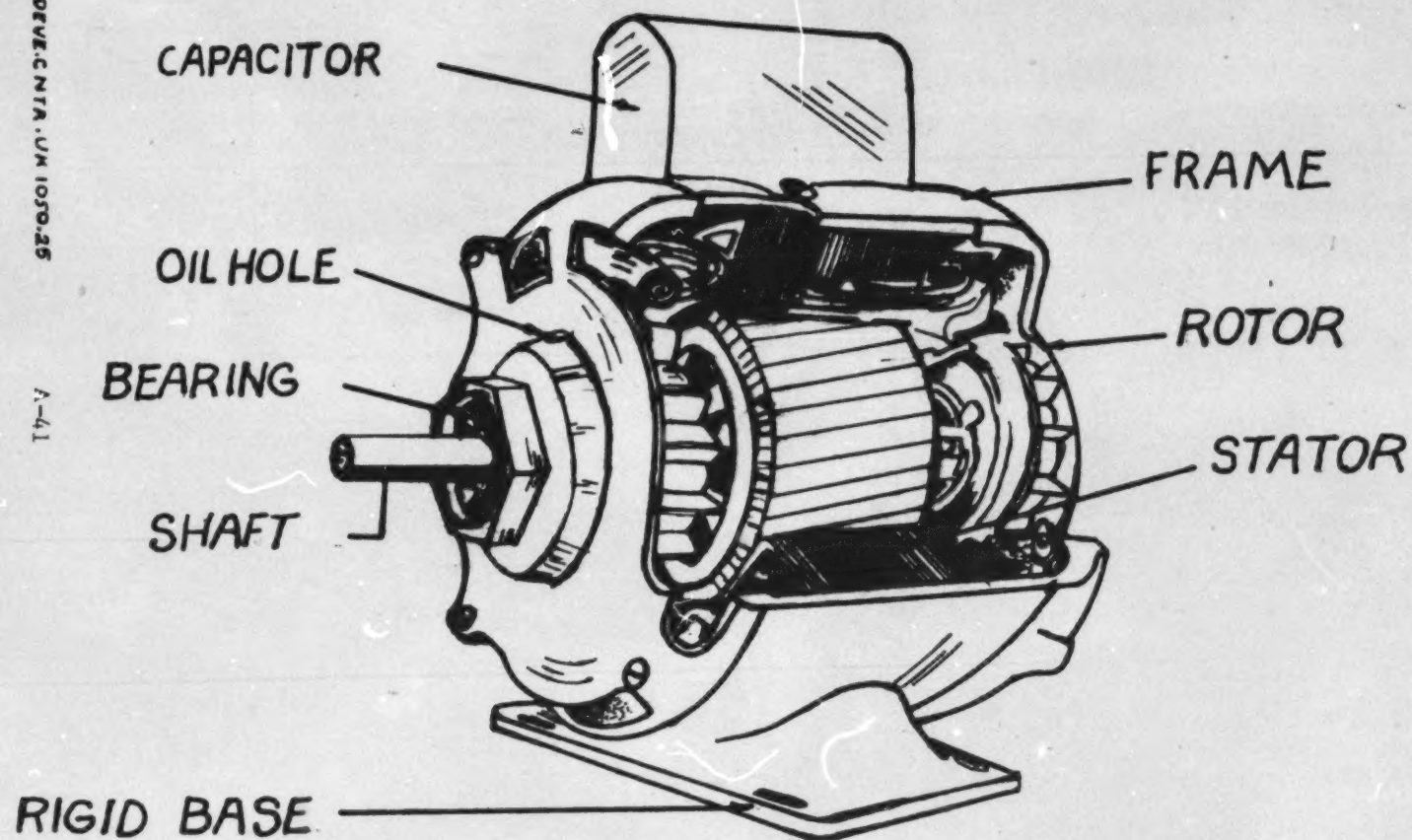


RING OILED

SPLIT-PHASE MOTOR

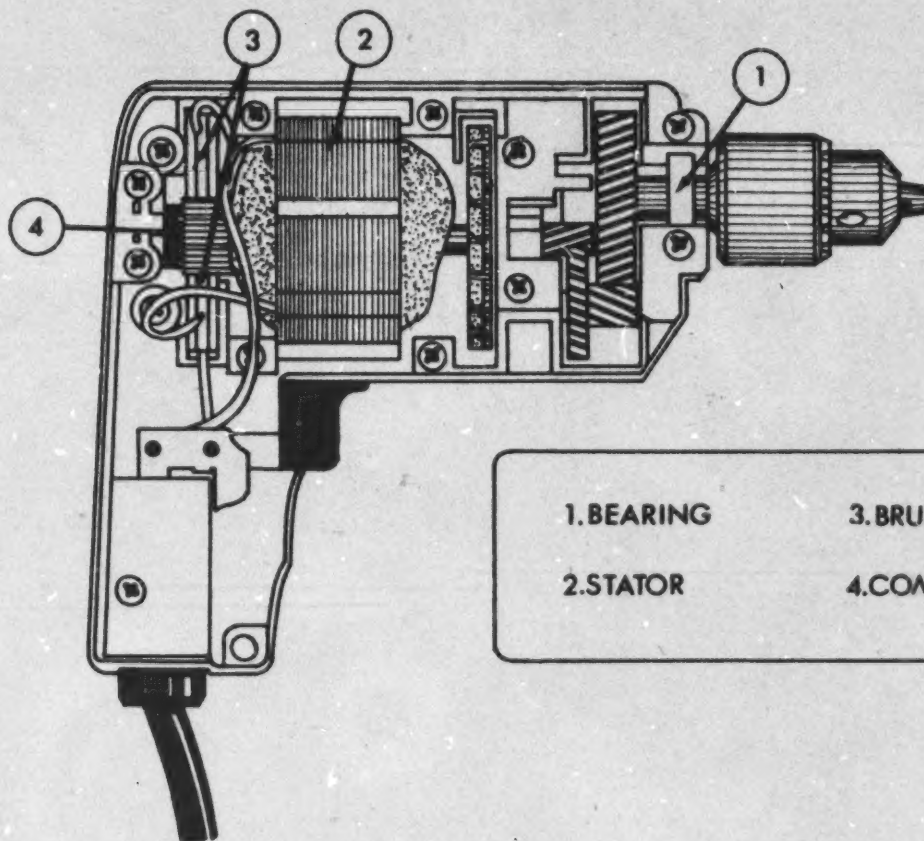


- | | | |
|----------------------|-------------------|------------------------|
| 1. END BELL | 5. SLEEVE BEARING | 9. COOLING VENT |
| 2. STARTING WINDINGS | 6. ROTOR | 10. COOLING FAN |
| 3. STATOR FRAME | 7. MOUNTING | 11. CENTRIFUGAL SWITCH |
| 4. MAIN WINDING | 8. THRUST WASHERS | 12. DRIVE SHAFT |



CAPACITOR MOTOR

UNIVERSAL MOTOR



1. BEARING

3. BRUSHES

2. STATOR

4. COMMUTATOR

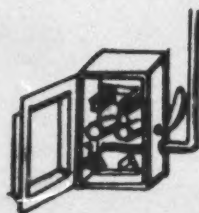
SERVICE ENTRANCES AND ACCEPTED MOTOR SIZE

30 AMPERE
2-WIRE
120 VOLTS
SINGLE PHASE

30 AMPERE
3-WIRE
120-240 VOLTS
SINGLE PHASE

60 AMPERE
3-WIRE
120-240 VOLTS
SINGLE PHASE

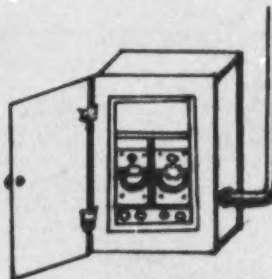
100 AMPERE
3-WIRE
120-240 VOLTS
SINGLE PHASE



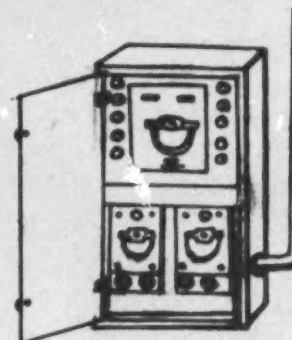
1/3 HP
OR SMALLER



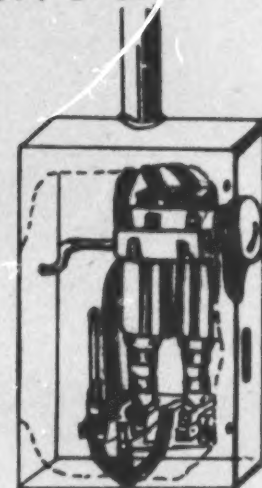
UP TO 1
OR 1 1/2 HP



UP TO 5 HP

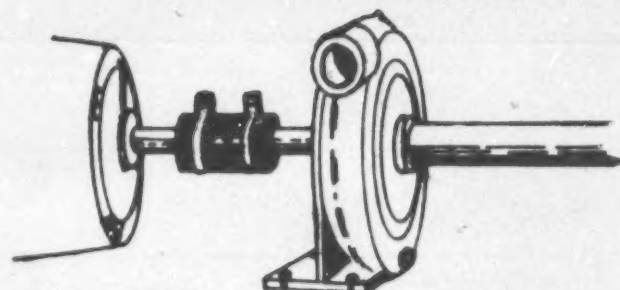


UP TO 7 1/2 HP

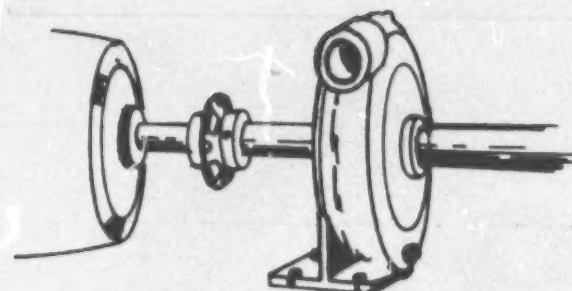


FOR LARGER
MOTORS

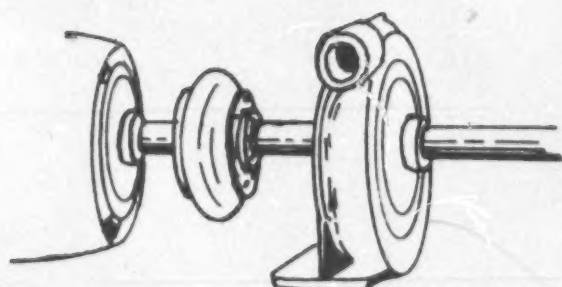
DIRECT DRIVES



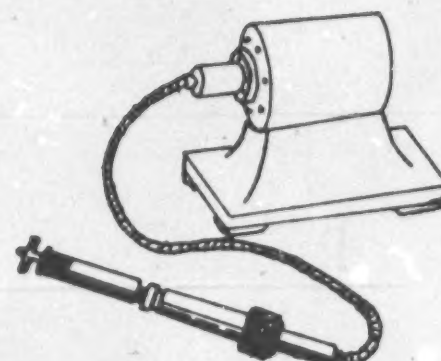
FLEXIBLE HOSE COUPLING



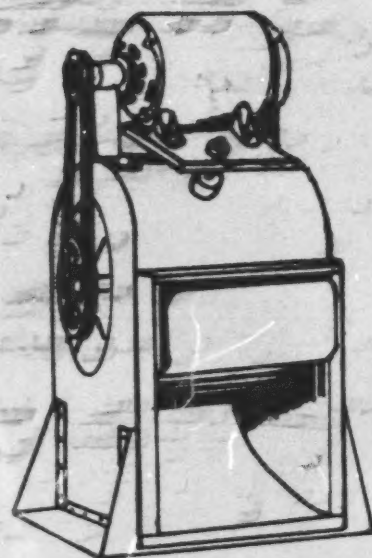
FLANGE COUPLING



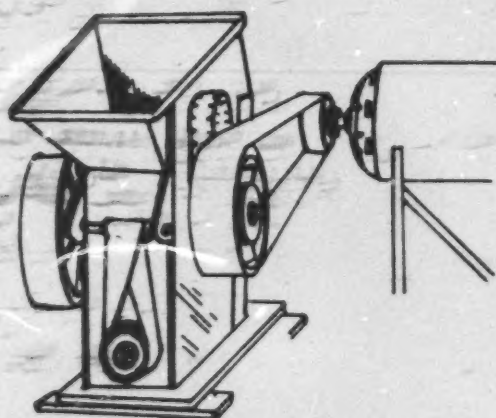
CUSHION-FLANGE COUPLING



FLEXIBLE SHAFT

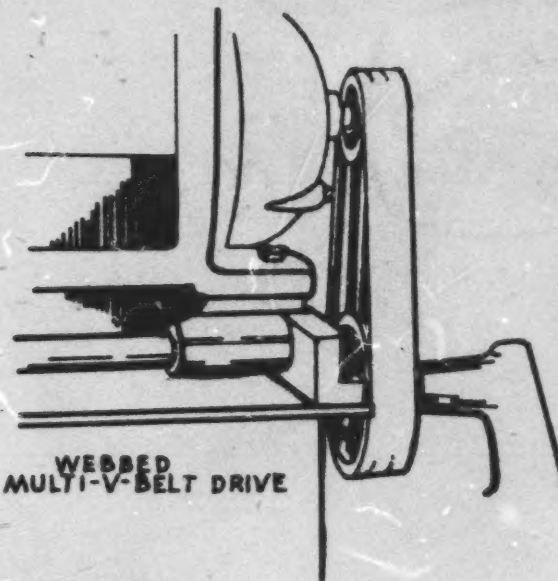


V-BELT DRIVE

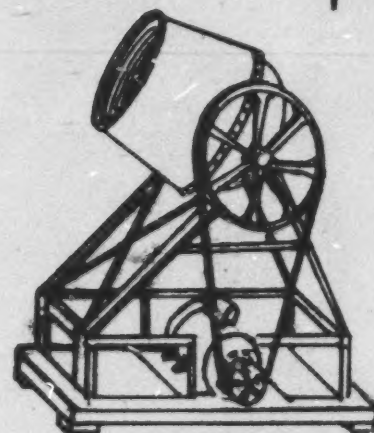


FLAT-BELT DRIVE

PULLEY AND BELT DRIVES



WEBBED
MULTI-V-BELT DRIVE

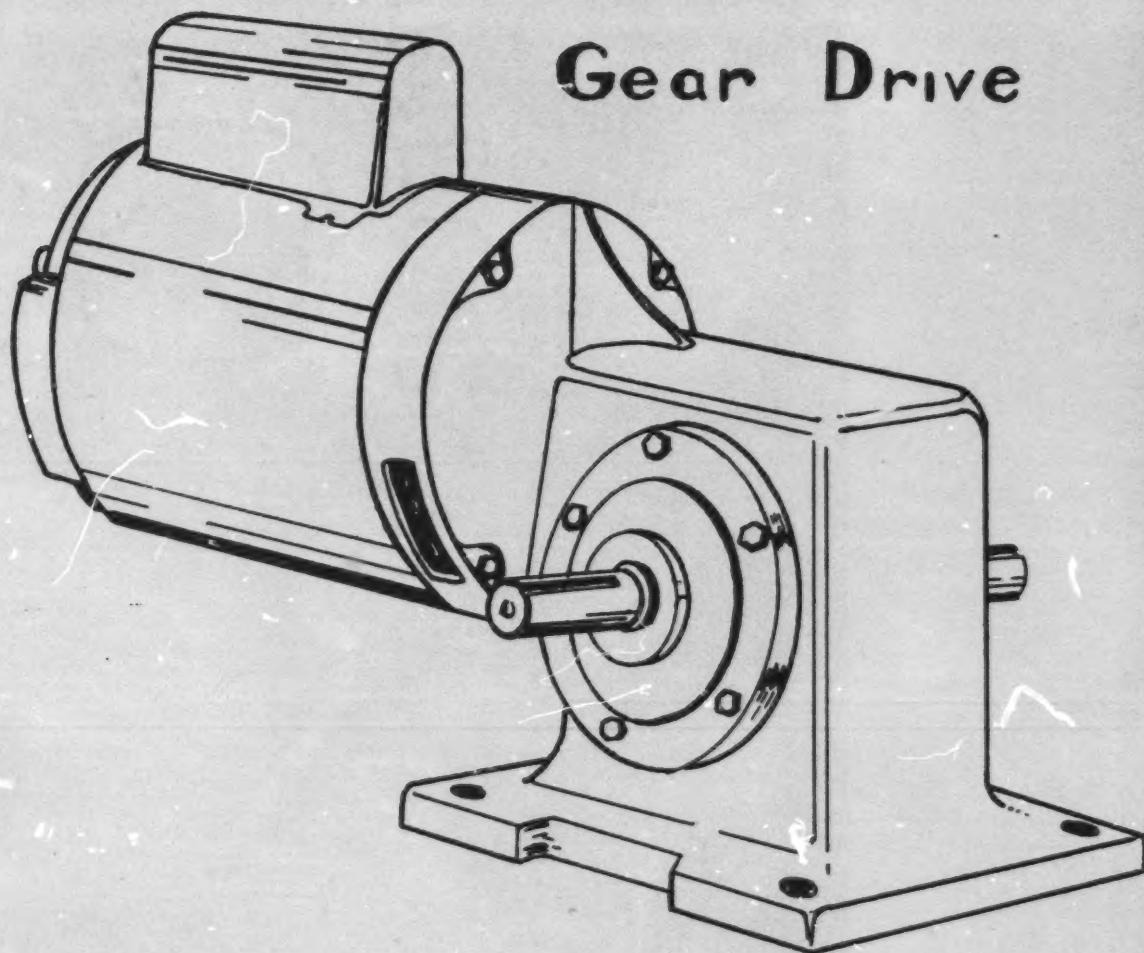


V-FLAT DRIVE

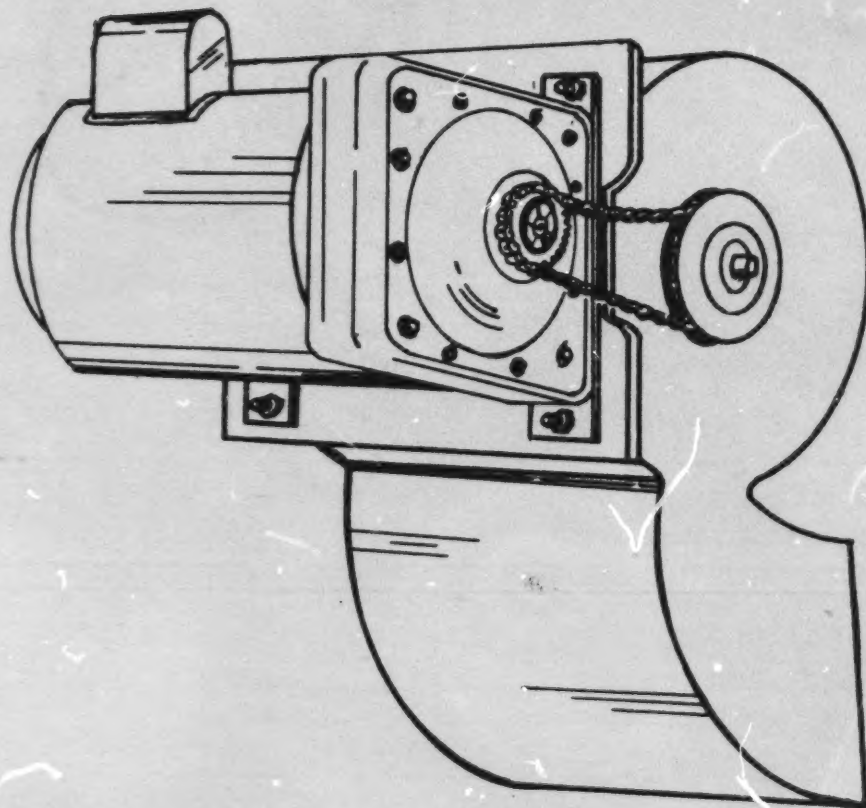
S. SPATZER, CURR. DEVE. CONTR. U.K. 1080. 21

A-46

Gear Drive



Chain and Sprocket Drive



JACKSHAFT PULLEY USE

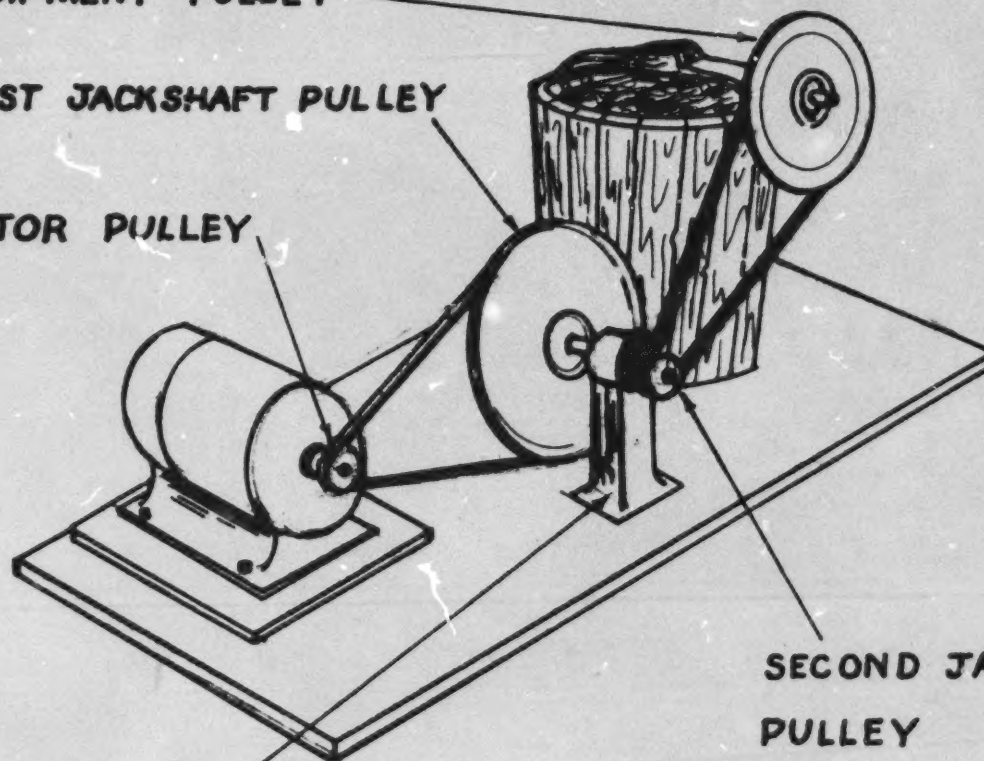
EQUIPMENT PULLEY

FIRST JACKSHAFT PULLEY

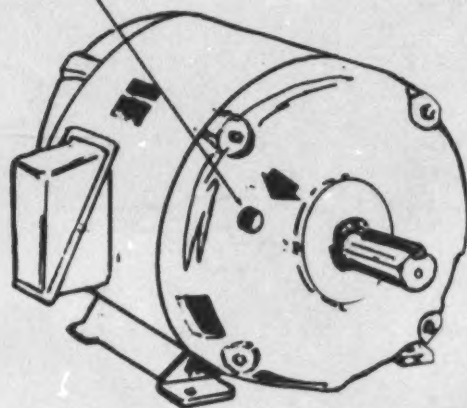
MOTOR PULLEY

SECOND JACKSHAFT PULLEY

JACK SHAFT

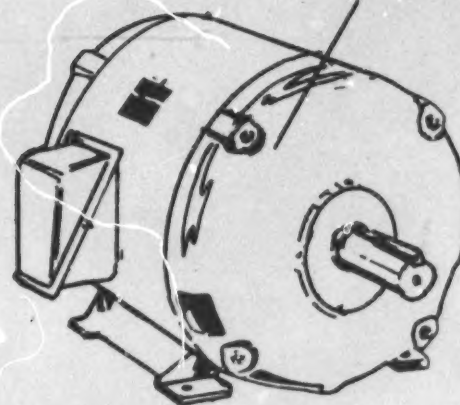


MANUAL-RESET
BUTTON



(a)

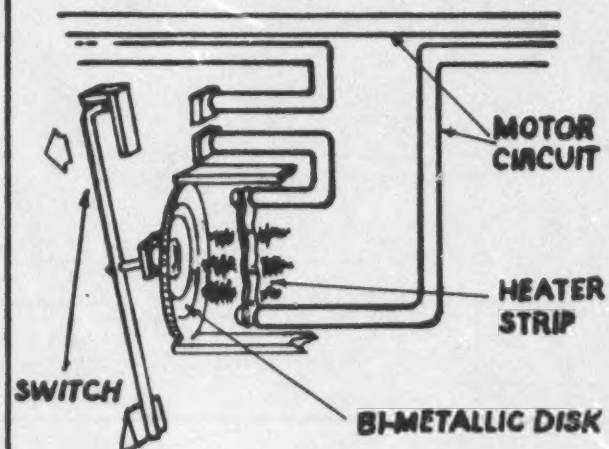
AUTOMATIC-RESET
(Inside Motor)



(b)

TYPES OF RESET BUTTONS

TRIPPED POSITION



REFERENCE LIST

Books:

Agricultural Wiring Handbook. Agricultural Marketing Division, Edison Electric Institute, 90 Park Avenue, New York, New York 10016, 1971.

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"How Electric Motors Start and Run." American Association for Vocational Instructional Materials, Engineering Center, Athens, Georgia.

PC-007 5722